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Research Article

Multimedia Principles Rubric: A New Instrument to Filter Instructional Science Videos Based on the Cognitive Theory of Multimedia Learning*

Fatma MOHAMED TAHER[1], Semiral ÖNCÜ[2], Yavuz SAMUR[3]

[1] Misrata University, Faculty of Science, Libya, ftm.taher02@gmail.com, http://orcid.org/0000-0002-9675-6763

[2] Balıkesir University, Necatibey Faculty of Education, Türkiye, semiral@gmail.com, http://orcid.org/0000-0001-8549-094X

[3] Bahçeşehir University, Faculty of Educational Sciences, Türkiye, yavuzsamur@gmail.com, http://orcid.org/0000-0003-4269-7099

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Abstract – Today's learners simply resort to the Internet to research and meet their learning needs, especially videos. Most such resources are unsupervised and of poor quality. However, there is a lack of instruments in the literature to measure the instructional quality of such widely available videos. Moreover, cognitive aspects are frequently overlooked when judging such content. In this study, an instrument called multimedia principles rubric (MPR) was developed after consultation with experts and evaluated to fill this gap. MPR consists of 16 principles based on Mayer's cognitive theory of multimedia learning (CTML) and has been fine-tuned through a literature review. Descriptive items of MPR are organized according to a 5-point Likert scale and produce an overall mean cognitive value score. MPR was tested by multiple raters on 90 sample physics videos that were selected through cluster sampling and found to have good interrater reliability. MPR can assist its users, especially teachers, in filtering videos in light of CTML rather than relying solely on statistical indicators such as video ratings or number of views. MPR is also beneficial for identifying gaps in educational content and recommending solutions for content producers to implement.

Keywords: Design principles, instructional video, multimedia, rubric, physics.

Corresponding author: Semiral ÖNCÜ, semiral@gmail.com

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Introduction

Instructional videos have become increasingly significant in education, especially in the recent new educational transition. Videos have been shown to be efficient educational resources for grabbing students' attention and allowing teachers to deliver personalized learning opportunities (Wang et al., 2016). In terms of theories on cognition, studies on multimedia for learning such as AlShaikh et al.'s (2024) aid in determining ways to plan and enhance utilization of videos in teaching and learning. Almost all studies of this sort, on the other hand, have researchers who produce their specific videos and utilize the videos purely towards their own interests, with background, subject matter, subjects, and even teachers monitored and research elements being overseen to the greatest extent feasible. On the contrary, in the actual life, learners are increasingly utilizing platforms like YouTube for educational purposes (Khan, 2017), highlighting the need to understand user engagement with online content. Videos are abundant but not always of good educational quality. This has not gotten adequate attention in the literature, and there has not been ample research done specifically for this purpose. For people who are dealing with the influx of materials from the Internet into educational settings, it has become a serious issue that there are not effective screening mechanisms (Bengfort, 2019). Filtration has become one of the most pressing issues in recent years, even though it was not previously as serious (Frick, 2020). Filtering content that is educational in nature becomes increasingly important to ensure that what viewers, or students, watch benefits them. One such filtering technique involves examining and categorizing videos based on product quality or content accuracy. However, some essential parts of this technique may be missing, including the attention to instructional design and pedagogical principles, which have been shown to be closely linked to the cognitive processes required for acquiring and handling new information (Tim Green, 2014).

An instrument can be helpful and is needed to improve the process of filtering the vast quantity of educational videos available on the Internet, especially on YouTube (Shoufan, 2019). Sweller's Cognitive Load Theory (CLT) and Mayer and Moreno's Cognitive Theory of Multimedia Learning (CTML) provide fundamental foundations for envisioning testable strategies for creating and judging instructional videos that produce desired effects. Such theory-based strategies can help understand the potential instructional value of educational videos in trendy video databases such as YouTube. They can improve the way educational videos are evaluated for educational purposes by taking into account not only video production and content quality but also instructional approaches and cognitive characteristics.

Driven by this motive, the current study was carried out to create an instrument to rate the cognitive merit of instructional videos using multimedia design principles as the primary evaluation criteria. It was undertaken in order to assist educationalists as well as learners in overcoming the difficulty of video content filtration, particularly on YouTube, and to assist them in exploring educational videos that can provide fruitful multimedia messages for learning. Accordingly, this study specifically addressed the research question, "What is a holistic rubric grounded on multimedia principles for instructional design to assess educational videos in order to contribute to learning?"

Theoretical Background

Multimedia learning (ML) within the scope of the current study, is the use of both words and pictures to present learning materials (Mayer & Moreno, 1998). Learning in multimedia environments has been the target of many research studies throughout the past decades. Several theories have emerged and been studied to understand how learning occurs in the mind and how multimedia learning can help promote the type of thinking needed in acquiring knowledge. Our study is based on CTML, which is grounded on other ML theories such as *Dual Coding Theory* (Paivio, 1978), *CLT* (Sweller, 1988) and *Generative Learning Theory* (Wittrock & Farley, 1989). CTML argues that in ML environments the mind is involved in five central cognitive processes that explain how the auditory and visual inputs are processed (Mayer, 2014b). The first two processes are *word selection* and *image selection* where learners pay attention to specific words or visuals from multimedia inputs, resulting in the creation of sounds or images in the working memory. Subsequent processes are *word* and *image organization* where the learner's mind focuses on discovering associations between the selected words or images to relate them to each other in the working memory to form a logical verbal or visual model mentally, respectively. The final process is *integrating representations* which refers to the learner's process of linking and making sense of information. CTML, thus, explains how involving certain cognitive processes enables students achieve beneficial learning from a mixture of text and images (Mayer, 2014a, 2014b).

Within the framework of ML, several design principles have been introduced and studied. Following are the names of some of the principles relevant to the current study and investigated by us in the process of creating the new instrument: Principle 1–*Coherence*, 2–*Signaling*, 3–*Redundancy*, 4–*Spatial Contiguity*, 5–*Temporal Contiguity*, 6–*Multimedia*, 7–*Segmenting*, 8–*Pre-Training*, 9–*Modality*, 10–*Personalization*, 11–*Voice*, and Principle 12–*Image*.

In addition to these classical principles, another principle that involves the use of on-screen agent, the same as Principle 12 (Image), has been presented in Mayer's work as Principle 13–*Embodiment.* More instructional and design elements have been evaluated, and relatively more complex principles have been established over the years (Fiorella, 2021), such as Principle 14–*Individual Differences*, 15–*Guided Discovery*, 16–*Worked-Out Examples*, 17–*Collaboration*, 18–*Self-Explanation*, 19–*Animation and Interactivity*, 20–*Site Map*, 21–*Prior Knowledge*, and Principle 22–*Cognitive Aging*.

Mayer et al. (2020) have recently proposed five new principles with the goal of improving the usefulness of instructional videos: Principle 23–*Dynamic Drawing*, 24–*Gaze Guidance*, 25–*Generative Activity*, 26–*Perspective*, and Principle 27–*Subtitle*. Principle 28–*Seductive Details* has also been presented in the same paper, but as something to be avoided.

The main purpose of the multimedia principles generally is to help learners minimize *extraneous cognitive load*, manage *intrinsic cognitive load*, and maximize *germane cognitive load*, which are the types of cognitive loads introduced by Sweller (1988) in CLT. This theory suggests that the working memory can only process a limited amount of information at a time (Leander et al., 2010), and CTML suggests some guidelines that focus on the presentation of information in the form of words and pictures with as much possible consideration of the three cognitive loads as possible.

The current paper is not intended to redesign, redefine, or restate the multimedia design theory nor its principles. Due to space limitations, the reader is kindly advised to consult Mayer's research and books (Mayer, 2014a, 2014b; Mayer & Moreno, 1998), in addition to his recent article with Fiorella, and Stull (Mayer et al., 2020) for the definitions of the principles. The intention here is to focus more on those that apply to video, which are further elaborated in the Method section.

Related Studies

The primary goal of utilizing multimedia in educational settings is to assist students in gaining and constructing knowledge, which necessitates the creation of mental representations from visual and verbal sources of input. Educational videos have to be produced with the intent of boosting relevant mental activity; or else, viewing them might just be an unproductive exercise (Berk, 2009; Brame, 2016; Veritasium, 2014). To investigate this issue more deeply, several research studies have been conducted to study the attributes of effective instructional videos, providing us with diverse lists of video features that are thought to lead

to powerful educational tools. Brame (2016) introduced and recommended some useful criteria for creating or selecting videos that achieve desired learning results: cognitive load, learner engagement, and active learning. Moreover, ten Hove and van der Meij (2015) suggested several guidelines to be respected to achieve the same goal: (1) Supporting the learning content with visuals, (2) Relying on narration more than on-screen text to present the learning content, (3) Offering closed captions as an optional feature, (4) Creating videos with high resolution and production quality, (5) Utilizing graphics components that are good in quality, (6) Avoiding any sound that is undesired or interferes with hearing in the background, (7) Providing visually descriptive examples to describe the learning content, (8) Displaying keywords on the screen, (9) Guiding learners' attention by emphasizing essential information on screen, and (10) Providing verbal directions. Furthermore, Berk (2009) stated that effective educational videos often consider common general features: (a) being short in length, preferably less than 3 minutes depending on the nature of content, (b) employing casual language, (c) using visual cues and excluding any irrelevant elements, and (d) being direct and restricting the number of characters. In another study, Kay (2014) classified 16 tested and proven guidelines designed to improve mathematics teaching through worked-example video podcasts into four broad categories: (i) establishing context, (ii) providing effective explanations, (iii) minimizing cognitive load, and (iv) engaging students. He found that paying attention to cognitive features like the segmentation of learning content, use of visuals, and fading out of steps to explain the relevant examples can influence learners positively.

Evidently, many of the guidelines in the literature are focused on the same concepts. Most of them are directly related to the cognitive features covered in the multimedia design principles. Coherence, multimedia, signaling, personalization, voice, and segmenting are some of the most widespread ones (Berk, 2009; Brame, 2016; Shoufan, 2019; ten Hove & van der Meij, 2015).

Most existing research in terms of instrument development did not primarily focus on cognitive learning. Only three studies were found that used an instrument to directly evaluate instructional YouTube videos rather than rating them based on viewer interactions (likes, dislikes, and views). One such instrument was in a thesis conducted by ten Hove (2014) who employed a 36-item questionnaire to assess 75 conceptual and instructional videos. The framework on which the questionnaire was developed had three design levels (physical, cognitive, and effective). The main outcome was a list of common characteristics found in popular instructional videos, which were turned into design guidelines: use different visuals to

support the learning, minimize on-screen text by relying more on narration and optional subtitles, have high production quality, use illustrative examples to support the theoretical explanation, and support the learning process by applying various elements (cues, keywords, spoken prompts). Some of these characteristics are closely related to multimedia design principles.

Another instrument, a modified version of the previous one, was developed by ten Hove & van der Meij (2015) in a study comparing popular YouTube instructional videos to non-popular and average ones. They reported characteristics consistent with the aforementioned physical dimension of popular videos: (1) high quality materials, (2) frequent use of static visuals, (3) frequent use of a mixture of static and dynamic visuals, (4) limited on-screen texts, (5) provision of subtitles in various languages, (6) using background music, (7) having less background noise, and (8) applying a faster narration rate.

In their studies, ten Hove (2014) and ten Hove & van der Meij (2015) presented several cognitive features in the instruments, but they did not utilize them to evaluate videos or attempt to link them to learning results (Shoufan, 2019). Nevertheless, there are instructional design strategies in their list of characteristics that would be favored by learners.

Another instrument was created by Shoufan (2019) and tested on a sample of 105 videos of five topics on digital logic design. Shoufan included the multimedia design principles and used them as indicators of video cognitive features. He assumed that cognitive features are binary in nature, so he evaluated the videos using a binary scale (0, 1). He introduced a new factor, "video cognitive value" (VCV), estimated from the interaction features on YouTube videos based on the results of a survey conducted on 428 students. According to Shoufan, learners' likes or dislikes of educational YouTube videos are related to their level of understanding and whether the videos provide them with the needed information or not (Khan, 2017).

A similar approach to the current study was found to be used in an article written by Kuzu et al. (2007). In that study, an instrument was designed based on the CTML to evaluate the quality of visuals in instructional materials. However, it targeted text books instead of videos. According to the authors, the instrument is generalizable by calculating the averages of different types of visuals or pictures presented in text books in terms of each criterion (multimedia design principle: concentrated, concise, correspondent, coherent, comprehensible, and codable). The visuals are examined to get their average scores out of 100, and then classified as "appropriate" (70 to 100), "should be revised" (50 to 70), and "not

suitable" (below 50). The average scores are estimated for each criterion and also for the book as a total.

The previous studies give a glimpse of the importance of scientific research in improving the design of instructional videos, thereby, boosting their viability as educational tools (Mayer, 2010). It is how you use a tool in education, not the tool itself, that matters, and mastering the ML theories can have a significant impact on how technology is used in educational settings. Accordingly, educators' main goal should be to support learners in experiencing meaningful thought processes and promote the type of thinking needed for learning (Veritasium, 2014). We aspire to contribute to the solution to this quest by providing a comprehensive rubric for rating educational videos.

Method

Research Design

The core of this study was to develop an instrument, first, by reviewing the previous literature regarding multimedia learning, characteristics of an effective educational/instructional video, and YouTube analysis, then by forming the instrument based on the results and findings reviewed, and finally by collecting data to build on and enhance the use of the new instrument and confirm its application to make it more reliable and generalizable (Creswell, 2005).

Multimedia Principles Rubric (MPR) Design Procedure

After reviewing literature on educational videos and YouTube clips, we found that most instruments and approaches are centered on production quality or content analysis, with the use of different instruments depending on discipline (explored further in the following paragraphs). Only a handful pay attention to instructional and design characteristics that may have an impact on learners' cognitive processing. Accordingly, the instruments found were unsuitable to address the current research question. Therefore, a new instrument called Multimedia Principles Rubric (MPR) was developed (Appendix A) based on the CTML to analyze instructional videos more purposefully. The multimedia design principles were the main themes of the rubric's items, criteria, and scale. In MPR, we refer to the principles as *items* so that it is clear that we are referring to the rubric, not the literature, whenever we mention them.

A relatively relevant instrument is presented in Shoufan's (2019) study by referring to VCV, as introduced earlier in this paper. Although it included a section to address cognitive

features, its binary scale is rather narrow, where 1="the video entirely and essentially supports the cognitive feature," and 0="the video does not entirely or essentially support the cognitive feature." This scale was initially tested in the current study, but it turned out that most videos were difficult to evaluate using only two options. Thus, MPR was constructed as a rubric to be more flexible and accurate in detecting gaps in instructional design and presentation of videos.

When developing MPR, we considered the design, implementation, and analysis processes of the instruments of Brame (2016) and ten Hove (2014). We used a five-point Likert scale to rate and classify videos more precisely, where 1="Very poor," 2="Poor," 3="Fair," 4="Good," and 5="Excellent." The *criteria* under each item explain a specific level of agreement with the corresponding concept rather than just simply assessing its presence or absence. Because the criteria are inherently lengthy, we have also created a concise version of the rubric to enhance clarity and usability. This short form, presented in Appendix B, allows for quicker reference and evaluation. As raters become more familiar with the criteria, they may find themselves relying primarily on the short form rather than the detailed version.

The left side of the rubric (Appendices A and B) displays labeled items, with item numbers assigned for identification purposes, without implying any specific order or hierarchy of importance. There is no distinction or rating indicating the superiority of one item over another. At the top row, you will find the presentation of the five scale levels mentioned earlier. Under them, the criteria for each item are listed.

It is important to mention that it is not necessary/reasonable for all of the rubric's items to be applicable to each video. There are videos where one or more MPR items may not apply. Such items are not included when determining the mean score for each video in MPR, but they are not missing values either. So, no videos were eliminated during the evaluation in this study. Basically, this is an assumption based on the idea that an instructional video does not have to adhere to all principles to be considered effective. However, when considering them, it has to be done appropriately or it might have no, little, or negative impact on learners. For example, if a video is designed in the Khan-Academy style, with no agent on the screen, then Principle 13 (embodiment I13) does not apply and will be classified as 'Not Applicable' (N/A) rather than 'Very Poor' (1), yet this does not negate the video's cognitive impact. However, if an animated video with an on-screen character fails to address Principle 13, then the cognitive impact on learners will be impaired (Fiorella & Mayer, 2018), corresponding to a lower cognitive value for the video.

Moreover, despite our conviction that each design principle's contribution to the overall cognitive impact on learners should not be equal, the rubric fails to meet this demand. As a result, while the rubric does not account for variances in the weights of distinct multimedia principles, it does give a sense of their individual contribution to the assessment.

Finally, the mean score of MPR can be used as an indicator of cognitive features of examined videos. This value is referred to as mean MPR score (M_{MPR}) throughout this paper. For each video it can be estimated using Equation 1.

$$M_{MPR} = \frac{\text{Summation of MPR item scores}}{\text{Number of items that apply to the video being evaluated}} \quad (1)$$

Equation (2) demonstrates how the width between cut points for M_{MPR} levels is determined:

$$\text{Level Width} = \frac{\text{Range of MPR scale (4)}}{\text{Number of levels (5)}} \quad (2)$$

The range is calculated as the difference between the lowest (1) and highest (5) scores on the five-point Likert scale (Alkharusi, 2022; Pagano, 2013). Using this framework, videos are classified into five cognitive levels: "Very Poor," "Poor," "Fair," "Good," and "Excellent." While these levels align with the MPR rubric's scale, classification is based on calculated M_{MPR} levels as follows:

Very Poor ($1.00 \leq M_{MPR} \leq 1.80$): Low cognitive value.
Poor ($1.80 < M_{MPR} \leq 2.60$): Low-medium cognitive value.
Fair ($2.60 < M_{MPR} \leq 3.40$): Medium cognitive value.
Good ($3.40 < M_{MPR} \leq 4.20$): High-medium cognitive value.
Excellent ($4.20 < M_{MPR} \leq 5.00$): High cognitive value.

This classification was reviewed and approved by the experts (details in the "Expert Review" section).

MPR Items

The MPR items (referred to as I01–I16, i.e., Item01–Item16) were formed based on Principles 1–13, which are known as the classical multimedia design principles, in addition to three new Principles 23, 24, and 27. These items are introduced very briefly below in this section; the reader is invited to review the MPR in Appendix A for a better understanding of

the incorporated principles and to refer to Mayer's studies (e.g., Mayer, 2014a, 2014b; Mayer & Moreno, 1998; Mayer et al., 2020) for more detailed descriptions.

I01–*Coherence*..... : exclude irrelevant and unnecessary material.
I02–*Signaling*..... : highlight key aspects and significant information.
I03–*Redundancy* ..... *:* use narration & graphics, rather than narration, graphics & text altogether.
I04–*Spatial Contiguity*..... : place relevant on-screen text & visuals near to each other.
I05–*Temporal Contiguity* *:* present relevant words & visuals together at the same time.
I06–*Multimedia* ..... : add pictures to words.
I07–*Segmenting* ..... : divide learning content into learner-pace segments rather than one continuous unit.
I08–*Pre-Training*..... : introduce the main terms & key concepts of leaning content at the beginning.
I09–*Modality* ..... : use narration rather than on-screen text to support the visuals.
I10–*Personalization*..... : use a conversational tone rather than a formal one.
I11–*Voice*..... : use a narration of a clear human voice rather than a robotic one.
I12–*Image*..... : having the narrator's image on the screen is not necessarily beneficial to learners.
I13–*Embodiment*..... : use an on-screen narrator\character that has a high embodiment.
I14–*Dynamic Drawing* .... : draw relevant visuals while lecturing rather than pointing to already drawn ones.
I15–*Gaze Guidance* ..... : the on-screen instructor shifts their gaze between the learning materiel and the camera rather than looking constantly at one of them.
I16–*Subtitle*..... : provide on-screen subtitles with a slow-paced narration or without a narration.

The conditions, or indicator expressions, specified within each rating level/column were inspired by Mayer's studies on the corresponding principles, except for Principle 27 (I16–subtitle), as it was originally considered for non-native learners (Mayer et al., 2020). The

straightforward application of this principle may conflict with Principles 3 and 9 (redundancy and modality, respectively). Therefore, to avoid the possible contradiction and to better generalize to a wider YouTube audience, the corresponding item (I16) was designed as a compromise solution for native and non-native speaker learners. The conditions or *criteria* within each rating level/column of I16 were modified in the current study to consider the three principles cited above, with priority given to Principle 27.

Except for the 16 principles just mentioned, the other multimedia principles were excluded from the scope of this study. For one thing, prior to the development of the MPR, an extensive list of principles was reviewed to select the principles applicable to video as a unit rather than to students in an academic context. Most of the principles eliminated are typically related to learners or learning settings rather than multimedia presentation or design, because assessing them in a video context would be challenging, if not impossible. Therefore, they are better studied in trial research because they involve modifying some factors and introducing learners to a new learning event that necessitates in-class facilitation. Another reason is that multimedia does not refer exclusively to videos; it can also encompass websites and various other media forms. Since this study is on videos, the principles that do not apply to videos were omitted. Other than that, there are several reasons why some of the principles were excluded.

Some were left out since they required direct interaction with students, which was not addressed in this research. An example is Principle 17 (collaboration), which suggests that collaborative online activities are an effective way for teachers to achieve the best outcome. This principle has specific considerations and "must-follow" guidelines such as selecting a suitable task, creating a communicative learning environment, and having teachers fulfill their responsibilities correctly. All those and more should be taken into account, or the collaborative activities may have the opposite effect (Mayer, 2014b). Principles 14, 18, 21, and 22 were excluded for the same or similar reasons.

Some principles were complicated in comparison to the classical ones, making them unsuitable for use in the same instrument. Such principles appear to have been created in a context-specific fashion, as they include more conditions and have some strict boundaries. In Principle 16 (worked-out examples), for example, Mayer (2014b) highlighted five strict criteria important for its implementation in a context of multimedia learning. For this reason, it was decided to exclude this principle even though it is important particularly in science education. The same was true for Principles 15 and 25.

Some principles were left out since they only apply to certain types of videos. For example, while being a principle that directly concerns a form of instructional video, Principle 19 (animation and interactivity) was dropped since it is confined to animated videos and includes some criteria that cannot be overlooked. Similarly, Principle 26 (perspective) is best applicable to experimental videos that show how to do certain things; hence it was omitted.

In the context of this study, Principle 28 (seductive details) was found to be almost identical to Principle 1 (coherence) in terms of cognitive features, so it was not covered in the rubric. Principle 20 (site map) was not included, either, because it works exclusively on sites with hypertext.

Instrument Validity and Reliability

To achieve acceptable levels of reliability and validity, this paper describes the important parts of the development process of MPR in detail throughout the paper to signify its reliability (Creswell, 2005). Other than that, experts in the field of instructional technology were involved throughout the different stages to establish validity (Creswell, 2005). Additionally, the rubric's interrater reliability was examined and reported (Creswell, 2005). And finally, concurrent validity was sought by comparing the rubric with a comparable index (Fraenkel et al., 2011).

Expert Review

The initial version of MPR was reviewed by four experts to confirm its validity: an expert on instructional design and technology with 9 years of experience, two experts on instructional systems technology with 4 and 13 years of experience, and an expert on computer education and instructional technology with 9 years of experience.

The experts revised the instrument and provided significant feedback regarding the items, levels, overall design, and application. Feedback was discussed in meetings lasting between one and two hours, and on some occasions up to three hours, before the content validity of MPR was approved. They were involved at various stages. One of the experts helped to improve the rubric from the early stages, giving feedback on which principles to include or exclude. He had some minor wording recommendations regarding the personalization, voice, and image principles that were incorporated into the rubric, and some initial criticism regarding the presence of possible cases. After negotiations, it was agreed that the possible cases were necessary to cover the variety of instructional videos, but they were improved in terms of expression. After this, the MPR had 16 items and was shared with the

other three experts. One's feedback focused on the harmony of the rubric and the proper way to design a rubric as a pedagogical tool. A third expert mentioned that the coherence item was the most problematic due to its overlaps with other items, so it had to be improved until the expert was satisfied with the final version, which was achieved by trying and rethinking it on different types of videos and considering the most common cases to include. The final expert provided feedback on the wording and length, helping improve the accuracy, conciseness, and scope of the rubric. He also provided feedback on the image and subtitle principles as well as the way the possible cases appeared on the rubric and the overall design of MPR. Overall, the coherence, image, and subtitle principles received the most critical discussion from the experts. After incorporating their recommendations, the final version of the MPR (Appendix A) was used to score the 90 videos included in this study.

Interrater Reliability

To establish the interrater reliability of MPR, an intraclass correlation coefficient (ICC) analysis was conducted. Two raters, each possessing expertise in physics as physics teachers, independently evaluated a set of 90 physics videos retrieved from the YouTube platform. These videos were selected using a cluster sampling approach: 5 physics topics (e.g., "Work and Energy") were chosen as search keywords, and for each topic, 6 videos were selected across 3 length categories (short: under 3 minutes (Berk, 2009); medium: 3-6 minutes; long: 6-20 minutes (Knott, 2020)). This resulted in a total of 5 topics × 3 lengths × 6 videos = 90 videos, ensuring a balanced representation of topics and video lengths. The raters were chosen based on their familiarity with the video content and proficiency in English, as the evaluation rubric was composed in English. To minimize the influence of personalized search algorithms, an incognito browser window was used during the video selection process.

Prior to the evaluation, raters received basic instructions from one of the researchers, including both the application of the MPR rubric and a general overview of multimedia learning principles. Raters then simultaneously, but independently, viewed and evaluated the videos. Each video was assessed item-by-item using the MPR. Raters were instructed to refrain from discussing their ratings with one another during the evaluation process. Each rater submitted their scores independently upon completion of their review of all videos.

The SPSS file contained two columns, each representing the ratings of a different rater. Each video received 16 ratings, corresponding to the 16 MPR items listed in rows. Interrater reliability was assessed using a two-way random effects ICC with absolute agreement and average measures in SPSS. This model was chosen to allow for generalization to a wider

population of raters with similar expertise. The results of the ICC analysis indicated a strong level of agreement among the two raters (ICC = 0.88, 95% CI [0.853, 0.902]), suggesting high interrater reliability for MPR (Koo & Li, 2016).

Following the evaluation of videos, raters provided qualitative feedback regarding the MPR. A recurring concern was the potential for confusion between items I12 (Image Principle) and I13 (Embodiment Principle). Initially, raters perceived the two principles as interchangeable, with some suggesting that the Image Principle might be redundant since the Embodiment Principle appeared to cover similar ground in a more holistic manner. Both principles involve the presence of an instructor or on-screen agent, which contributed to this confusion. However, after clarifying the distinctions—where the Image Principle evaluates whether the instructor's image is shown and its purpose, and the Embodiment Principle assesses the instructor's use of gestures, expressions, and movements to enhance engagement—raters recognized the unique importance of each principle.

To address this issue, raters were provided with a clear example: in a Khan Academy-style video where only the content is displayed and the instructor's face is absent, the Image Principle would be rated highly, while the Embodiment Principle would be non-applicable. Over time, with repeated use of the rubric, raters became more adept at distinguishing between the two principles, leading them to revisit their previous ratings to ensure accuracy and consistency. The raters also noted that the detailed levels and descriptors for each rubric item helped them better understand and check the corresponding principles.

Furthermore, raters noted that accurate evaluation of certain items, particularly I01 (Coherence), may necessitate subject matter expertise like theirs. Despite these concerns, raters generally expressed positive feedback regarding the rubric's usability, noting that it facilitated a more structured and confident evaluation process, particularly given the diversity of video content encountered. While raters found the rubric to be somewhat verbose, they acknowledged that the level of detail was necessary to adequately address the wide range of video characteristics observed.

Findings

The final version of the MPR is presented in Appendix A, with its short form in Appendix B. Each of the 16 MPR items has a five-level description of what may be expected from a video's instructional quality and content. A YouTube video, "Work and Energy" by

"Professor Dave Explains," was rated using MPR as an example. The results are illustrated in Table 1.

Table 1 An Example Evaluation of the Video "Work and Energy" Using MPR

		Example video 1	
MPR Items		Score	Rating
I01	Coherence	5	Excellent
I02	Signaling	5	Excellent
I03	Redundancy	4	Good
I04	Spatial contiguity	5	Excellent
I05	Temporal contiguity	5	Excellent
I06	Multimedia	5	Excellent
I07	Segmenting	5	Excellent
I08	Pre-training	5	Excellent
I09	Modality	5	Excellent
I10	Personalization	4	Good
I11	Voice	5	Excellent
I12	Image	1	Very Poor
I13	Embodiment	2	Poor
I14	Dynamic drawing	2	Poor
I15	Gaze guidance	1	Very Poor
I16	Subtitle	5	Excellent
	Total	64 (n=16)[a]	

[a]n denotes the frequency of MPR items that apply to the video

M_{MPR} for this particular video was found to be 4.00. In Table 1, *n* denotes the frequency of MPR items that apply to the video.

Although it is difficult to demonstrate in a paper how the videos were reviewed without playing them, Figure 1 and Figure 2 provide screen captures of the reviewed YouTube video to demonstrate the existence of cognitive features to the greatest extent possible.

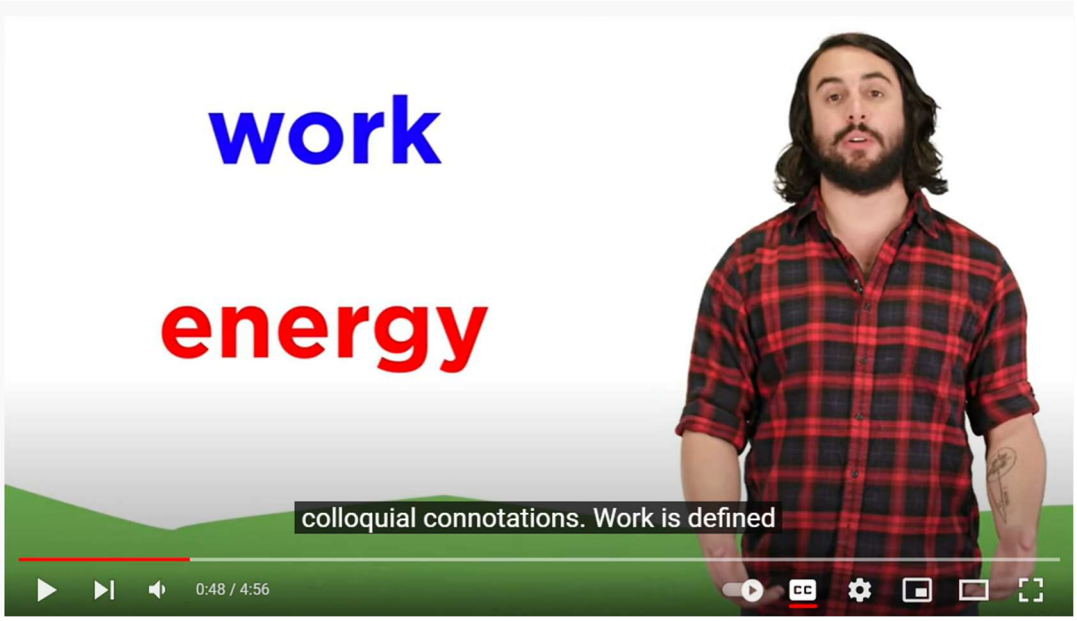

Figure 1 A Screenshot from the Reviewed Video "Work and Energy" Demonstrating Coherence (I01), Signaling (I02), Redundancy (I03), Personalization (I10), Image (I12), and Subtitle (I16) in MPR

Figure 2 A Screenshot from the Reviewed Video "Work and Energy" Demonstrating Multimedia (I06), Embodiment (I13), Dynamic Drawing (I14), and Gaze Guidance (I15) in MPR

Figure 1 presents an idea of the effectiveness of some items such as, coherence (I01), signaling (I02), redundancy (I03), personalization (I10), image (I12), and subtitle (I16). Figure 2 is a screenshot from the same video displaying multimedia (I06), embodiment (I13), dynamic drawing (I14), and gaze guidance (I15).

Discussion

MPR utilizes 16 principles of multimedia design as a rubric to assist educators in choosing the most useful videos as instructional tools out of the numerous available on the Internet, all based on CTML. If used suitably, those principles are thought to yield effective results; nevertheless, "the cognitive theory of multimedia learning is dynamic. Therefore, the twelve principles should not be taken as a rigid canon, but rather a starting point for discussion" (Sorden, 2013, p. 159). Thus, this rubric was developed and should also be regarded as a dynamic scale. Its items and criteria can be enhanced. It is possible to incorporate more items and criteria into it, but this will likely render it more complex, and verbose, which are typical shortcomings of rubrics, making them less useful.

MPR paves the way for the quantitative examination of cognitive features of instructional videos (i.e., various statistical tests may be run on them), while the full description at each level allows for the qualitative understanding of the same features.

MPR is a comprehensive and useful instrument, but it may not be useful to just anybody as some items require being a subject matter expert (SME) at least to some extent. For example, since deciding whether elements in a video are relevant or not can be done by those who know the learning content, it is suggested that the coherence principle (I01) is evaluated by SMEs. Because teachers are SMEs of their own disciplines, they should easily be able to benefit from MPR.

Segmenting suggests that multimedia-supported materials give learners a certain level of control over the instructional unit (Mayer, 2014b). Therefore, an instructional video should be well-structured. It should have distinct learner-paced pieces as well as options for speed control, volume adjustment, playing/replaying/stopping/pausing, and back and forth skipping. Because YouTube provides such options at present, this criterion was disregarded in MPR, but it should be checked in other video sources.

It is probable that the "accent" aspect of the voice principle (I11) is valid only for native learners watching a video in their own language narrated by a non-native speaker. So, if the narrator of a video has a heavy Chinese accent, for instance, Chinese audience are unlikely to be upset by the narration, at least not to the same extent as native speakers or even other non-native speakers. It is crucial to note that this is only a supposition intended to explain why certain videos that contravene the principle of voice in terms of accent are popular. So, more research is necessary to confirm or refute this supposition. One other factor to bear in mind

about the voice principle is that at level 1, "very poor," the first criterion is sufficient to specify whether a video falls into this category/level. At upper levels, however, it is essential to seek out all criteria.

Image (I12) refers to all forms of narrators that appear on screen, not just characters called talking heads, as is usually assumed. Although studies disagree on this principle, still images, talking heads, or character animations are all valid, Mayer (2014b) claims. Nevertheless, in order to truly comprehend and implement this principle, it is necessary to recognize its relationship with embodiment (I13). The majority of the favorable image principle results (presenting effect sizes that are medium or high) were linked to an agent or a drawn character who exhibited a significant level of embodiment, interacting with the viewer to the greatest extent possible through gaze, directing attention, gestures mimicking humans, facial expressions, and motion. If these features are not available, having no character in the video is more effective. This requirement was included in the relevant MPR items because it is considered a major criterion regarding the image principle (Mayer, 2014b). The image principle (I12) was also reported by the raters to be somewhat harder to judge at least at the beginning of their use of MPR.

Gaze guidance as a principle (I15) was initially developed as a result of research on lesson videos with a teacher on the screen. In this respect, eye contact and gaze shifting via the camera are accounted for between the teacher and students. However, when testing YouTube videos, particularly the ones with character animation, such gaze guidance was found to be non-applicable. According to Mayer et al. (2020), the key social premise emphasized by this principle is eye contact — not the agent — which assists viewers in establishing a partnership with the teacher and can be true for any on-screen agent. Therefore, based on theoretical considerations, gaze shifting was counted for any form of on-screen agent in the current study.

As it can be seen in the MPR, the subtitle principle (I16) is based on two criteria: displaying on-screen text as subtitles and delivering narration in a slow way. This principle was created with learners who are learning anything in a language other than their native language in mind. For that reason, for native speakers, its presence may conflict with certain other principles, particularly with redundancy and modality (I03 & I09) (Mayer et al., 2020). Since there can be two kinds of viewers (native and non-native), the rubric incorporated a balanced option that gives priority to second-language learners but still considers native speakers. This was accomplished by reminding the rater to look for the availability of optional

subtitles, which second-language viewers can use directly whereas native viewers can switch them off to avoid redundancy. MPR allows a video to be rated 5 "excellent" in terms of subtitles, if it appeals to both kinds of viewers, keeping in mind that the priority is given to the redundancy effect before modality as emphasized by Mayer et al. (2020). The first criterion at *level 5* (I16) is backed by Shoufan's (2019) findings which suggest that native speakers' YouTube videos are more likely to be enjoyed by viewers. The second criterion (I16), however, contradicts his findings, which demonstrate that YouTube providers with faster speaking speeds are more likely to be enjoyed by viewers. This was also one of the findings of ten Hove (2014), and ten Hove & van der Meij (2015) as well as Guo et al. (2014), but the latter's findings were related to videos in MOOCs. More research on this principle is needed to explain the lack of consistency in findings. One argument is that the subtitle principle was considered for non-native learners who may not represent most learners in the videos sampled for the research cited above and particularly that the videos in question may not be videos on science, which amount to Mayer's main focus. Or, simply put, popularity does not ensure the success of educational videos.

As is known, MPR is an instrument that was tested on a number of YouTube videos, and the main limitation in such samples is the fact that it is not possible to find out who watches them. This complicates the task of selecting appropriate content and design principles, because principles that benefit people with limited knowledge might not benefit people with superior knowledge (Mayer, 2014a). This means that people who design such videos or use them must check the presence of suitable principles and take them into account for certain learners, otherwise their endeavors will be in vain. The stated issue is among the justifications for why certain principles were left out of the rubric since their light application may exacerbate rather than alleviate learning-related struggles.

Shoufan (2019) proposed a video cognitive value (VCV) indicator depending on viewers' ratings, especially the number of likes, to rate the popularity of YouTube videos. He found cognitive features are partially significant for VCV, but the main reason why people like educational videos is the ability the videos offer for them to understand content. This finding is in line with ours because, as per CTML, a video's adherence to multimedia and instructional design principles are strongly tied to its content's understandability. This is why MPR was founded on the multimedia principles as the first consideration. This can be better realized if one recalls that the primary goal of establishment of the principles was to assist learners in taking part in a deep learning experience by handling the cognitive loads theorized

in CLT — extraneous, intrinsic, and germane cognitive loads (Mayer, 2014a). Although Shoufan argues that VCV is a suitable instrument for assessing instructional effect on learning, it may not be the greatest technique to assess the cognitive merit of instructional science videos. Techniques that rely on people's self-reports such as likes/dislikes on YouTube and surveys/questionnaires are not necessarily ideal ways to look into learning results. Muller elaborated on this concept in a Ted Talk, using examples and facts to show how learner's pre-knowledge can lead them to believe that they understand the content (TEDTalentSearch, 2012). To overcome this issue, he stated that the way you present content might affect the way viewers watch it and thus the extent to which they come to know, which is precisely what M_{MPR} is intended to convey.

Conclusions and Suggestions

Instruments to measure the instructional quality of widely available videos are lacking in the literature. What is more is that while judging online instructional content, cognitive aspects are frequently overlooked. In this study, the multimedia principles rubric (MPR) was developed and evaluated to fill this gap. MPR can assist its users in filtering videos in the light of CTML rather than solely depending on video ratings or number of views. MPR is also beneficial for identifying instructional content gaps and recommending a certain level of solutions for content producers to implement. The mean value of MPR (M_{MPR}) is proposed to determine the cognitive value of instructional videos. This value offers the potential to investigate variations and relationships among a variety of aspects (such as the learning content, duration, popularity of videos and so on) and how videos impact learning.

We believe the rubric in its current form will be useful to creators and producers of video content, designers of massive open online courses, instructional designers, educators, as well as teachers, by assisting in the filtering and design of more effective multimedia productions that capture the attention of viewers and prolong their engagement in a deeper learning experience. Notably, the rubric is not intended to directly minimize extrinsic load, manage intrinsic load, or maximize relational load; rather, it filters for videos that are designed to address these challenges. In this way, content creators who adhere to the rubric's principles can better overcome these load challenges, and educators who select videos accordingly can more effectively support their students.

Although every attempt was made to construct a comprehensive rubric, it can yet be improved. Further studies would be useful to corroborate and endorse our findings, as well as to enhance MPR. One such study can be on transforming MPR into a survey form that is even

more user friendly for instructors who are not much knowledgeable about the multimedia design principles. By analyzing the relationship between M_{MPR} and learner performance, experimental studies might be one other prospective research approach to test MPR's generalizability. Examining the link between M_{MPR} and VCV would also be a worthwhile endeavor. Another possible future study would be to explore how to incorporate the multimedia design elements that have been left out in this study. A final suggestion would be to look into the possibility of improving the rubric using the worked-out examples concept, building on Kay (2014) and Kay & Ruttenberg-Rozen (2020).

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

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CRediT author statement

Fatma Mohamed Taher: Conceptualization, Methodology, Formal Analysis, Writing - Original Draft.

Semiral Öncü: Data curation, Validation, Writing - Reviewing & Editing.

Yavuz Samur: Investigation, Supervision, Methodology.

Research involving Human Participants and/or Animals

This study involves no human participants or animal subjects.

Çoklu Ortam Prensipleri Rubriği: Çoklu Ortamla Bilişsel Öğrenme Kuramına Dayalı Fen Öğretimi Videolarını Filtrelemek İçin Yeni Bir Araç

Özet:

Günümüz öğrencileri, araştırma yapmak ve öğrenme ihtiyaçlarını karşılamak için basitçe internete, özellikle de videolara, başvurmaktadır. Bu tür kaynakların çoğu denetimsiz ve niteliksiz olabilmektedir. Ancak, literatürde bu tür yaygın olarak bulunan videoların öğretim kalitesini ölçen araçların eksik olduğu göze çarpmaktadır. Dahası, bu tür içerikleri değerlendirirken bilişsel yönler sıklıkla göz ardı edilmektedir. Bu çalışmada, uzmanlarla gözden geçirildikten sonra çoklu ortam (multimedya) prensipleri rubriği (MPR) adı verilen bir araç geliştirilmiş ve bu boşluğu doldurmak için değerlendirilmiştir. MPR, Mayer'in Çoklu Ortamla Bilişsel Öğrenme Kuramı'na (CTML) dayanan 16 ilkeden oluşmaktadır ve literatür taraması yoluyla detaylandırılmıştır. MPR'nin tanımlayıcı maddeleri, 5 puanlık bir Likert ölçeğine göre düzenlenmiştir ve genel bir ortalama bilişsel değer puanı üretmektedir. MPR, küme örneklemesiyle seçilen 90 örnek fizik videosu üzerinde birden fazla değerlendirici tarafından test edilmiş ve iyi bir değerlendiriciler-arası güvenilirliğe sahip olduğu bulunmuştur. MPR, kullanıcılarına, özellikle öğretmenlere, yalnızca video derecelendirmeleri veya görüntüleme sayısı gibi istatistiksel göstergelere güvenmek yerine, videoları CTML ışığında filtrelemede yardımcı olabilir. MPR'nin ayrıca eğitim içeriğindeki boşlukları belirlemek ve içerik üreticilerinin uygulayabileceği çözümler önermek için de faydalı olabileceği düşünülmektedir.

Anahtar kelimeler: Tasarım ilkeleri, öğretici video, multimedya, değerlendirme ölçütü, fizik.

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Appendix A

MPR DETAILED FORM

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	VERY POOR 1	POOR 2	FAIR 3	GOOD 4	EXCELLENT 5
I01 COHERENCE	None of the multimedia elements (visuals / text / sounds) in the video are related or essential for the learning content. The video has complex and distracting backgrounds (visuals / sounds).	Most of the multimedia elements (visuals / text / sounds) in the video are not related or essential for the learning content. The video may have complex or distracting backgrounds (visuals / sounds).	Some of the multimedia elements (visuals / text / sounds) in the video are not related or essential for the learning content. The video may have complex or distracting backgrounds (visuals / sounds).	Most of the multimedia elements (visuals / text / sounds) in the video are directly related and essential for the learning content. The video has simple and clear backgrounds (visuals / sounds). **OR** All of the multimedia elements (visuals / text / sounds) in the video are directly related and essential for the learning content. The video has complex or distracting backgrounds (visuals / sounds).	All of the multimedia elements (visuals / text / sounds) in the video are directly related and essential for the learning content. The video has simple and clear backgrounds (visuals / sounds).
I02 SIGNALING	None of the important elements are highlighted in the video's screen. Learners cannot spot the significant information of the learning content. None of the design features are used in the video.	The video highlights few important elements on the screen. The video points out few significant information from the learning content. The keywords are emphasized with a poor choice of features.	The video highlights some of the important elements on the screen. The video points out some of the significant information of the learning content. The keywords are emphasized with a poor choice of features.	The video highlights most of the important elements in the learning content on the screen. The video points out most of the significant information of the learning content. Various cues and features are used properly to emphasize on the keywords (such as: arrows, font, size, color, or spoken emphasize). **OR** The video highlights all of the important elements in the learning content on the screen. The video points out all of the significant information of the learning content. The keywords are emphasized with a poor choice of features.	The video highlights all of the important elements in the learning content on the screen. The video points out all of the significant information of the learning content. Various cues and features are used properly to emphasize on the keywords (such as: arrows, font, size, color, or spoken emphasize).
I03 REDUNDANCY	The narrator of the video reads on-screen text throughout the whole video to explain the visuals. Narration, on-screen text, and visuals all are presented simultaneously throughout the whole video.	The narrator of the video reads on-screen text most of the time to explain the visuals. Narration, on-screen text, and visuals are presented simultaneously throughout most of the video.	The narrator of the video sometimes reads on-screen text to explain the visuals. Narration, on-screen text, and visuals are presented simultaneously throughout some parts of the video.	The narrator of the video rarely reads on-screen text to explain the visuals. Narration, on-screen text, and visuals are rarely presented simultaneously throughout the video.	The video has only narration to explain the visuals (supported by on-screen keywords). Narration, on-screen text, and visuals are not presented simultaneously at all throughout the whole video. **OR** The video has only on-screen text to explain the visuals. Narration, on-screen text, and visuals are not presented simultaneously at all throughout the whole video.
I04 SPATIAL CONTIGUITY	None of the related text & visuals presented in the video are physically close to each other on the screen rather they are separated and presented in different slides (It is hard to know where to look for information in the video).	Most of the related text & visuals presented in the video are not physically close to each other but still appear on the same slide rather than different ones (It is hard to know where to look for information on the screen).	Some of the related text & visuals presented in the video are physically close rather than far from each other on the screen (Text & visuals can be related but not easily).	Most of the related text & visuals presented in the video are physically close rather than far from each other on the screen (text & visuals can easily be related).	All of the related text & visuals presented in the video are physically close rather than far from each other on the screen (text & visuals can easily be related).
I05 TEMPORAL CONTIGUITY	Words (narration / text) & visuals are never presented simultaneously (words are displayed before / after the visuals).	Words (narration / text) & visuals are not presented simultaneously throughout most of the video.	Words (narration / text) & visuals are presented simultaneously rather than successively only throughout some parts of the video.	Words (narration / text) & visuals are presented simultaneously rather than successively throughout most of the video (the video only misses the timing in few times).	Words (narration / text) & visuals are always presented simultaneously rather than successively throughout the whole video.
I06 MULTIMEDIA	The video does not have any visuals to support the words (narration / text) in explaining the learning content, rather, only words are used.	There are few (only one or two) relevant visuals to support the words (narration / text) in explaining the learning content throughout the video (not enough to cover the learning content).	There are some relevant visuals to support the words (narration / text) in explaining the learning content at some parts of the video (still not enough to cover the learning content).	There are relevant visuals to support the words (narration / text) in explaining the learning content throughout most of the video.	There are always relevant visuals to support the words (narration / text) in explaining the learning content throughout the video (enough to cover the learning content).

MPR DETAILED FORM	VERY POOR 1	POOR 2	FAIR 3	GOOD 4	EXCELLENT 5
Page 2 of 3					
I07 SEGMENTING	The video's pace is too fast for learners to adequately process the information. Too much information and complicated concepts are packed in the video. (Continues unit with a fast pace)	Most of the information in the video is presented at a fast-pace. Most of the learning concepts are packed in the video instead of being segmented.	Some of the information in the video is presented at a learner-pace. Some of learning concepts are divided into smaller segments throughout the video. **OR** The current video is part of a series of related videos that presents some of the information at a learner-pace. Some of the learning concepts are divided into smaller segments throughout the video series mentioned in the current video.	Most of the information in the video is presented at a learner-pace. Most of the Learning concepts are divided into smaller segments throughout the video. **OR** The current video is part of a series of related videos that presents most of the information at a learner-pace. Most of the learning concepts are divided into smaller segments throughout the video series mentioned in the current video.	All of the information in the video is presented at a learner-pace. All of the Learning concepts are divided into smaller segments throughout the video. **OR** The current video is part of a series of related videos that presents information at a learner-pace. All of the learning concepts are divided into smaller segments throughout the video series mentioned in the current video.
I08 PRE-TRAINING	No introduction / guide is given at the beginning the video. The video does not mention any key terms, concepts, or definitions regarding the learning content (the video jumps directly to the topic).	A short general introduction of the purpose of the video is given at the beginning where the learning content is mentioned but not explained. The video does not mention the key terms, concepts, or definitions regarding the learning content (only the title and the topic area are given with no terms, concepts, or definitions).	A short general introduction about the learning content is given at the beginning of the video. The video does not mention the key terms, concepts, or definitions regarding the learning content directly (only the main topic is introduced without its terms, concepts, or definitions).	An introduction / guide is given at the beginning of the video. The video mentions the key terms, concepts, or definitions regarding the learning content at the introduction / guide and refers to other videos to cover them (presenting the links on the video itself or in the description box).	An introduction / guide is given at the beginning of the video. The video introduces the key terms, concepts, or definitions regarding the learning content at the introduction / guide.
I09 MODALITY	The video uses on-screen text rather than narration to explain or support visuals. Narration may be used in the video but not for the purpose of supporting the visuals.	The video relies on on-screen text more than narration to explain or support visuals. On-screen text is used with both simple and complex visuals throughout most of the video.	The video relies on narration more than on-screen text to explain or support visuals. The video has some parts where the narration is used with visuals and other parts where on-screen text is the format used, without consideration of the complexity of the visuals and the pace of lesson.	The video uses narration more than on-screen text to explain or support visuals. On-screen text is used with simple visuals in the video, but only narration is used when the visuals are complex and the lesson is fast-paced.	The video always uses narration rather than on-screen text to explain or support visuals. On-screen text may be used in the video but not simultaneously with visuals (with the exception of keywords and labels).
I10 PERSONALIZATION	The video uses words (narration / text) in a formal style rather than a conversational style. The video relies on third-person statements rather than first and second-person statements (you, I, we, our). The video uses overly professional language and complex words (narration / text) instead of simple and casual language. The video has a formal serious tone without making direct comments to the learner.	The video uses words (narration / text) in a formal style more than a conversational style. The video relies on third-person statements more than first and second-person statements (you, I, we, our) most of the time. The video involves overly professional language and complex words (narration / text) instead of simple and casual language most of the time. The video has a formal serious tone without making direct comments to the learner.	The video uses words (narration / text) in conversational style more than formal style. The video relies on first and second-person statements (you, I, we, our) more than distant third-person statements. The video involves some overly professional language and complex words (narration / text) instead of simple and casual language. The video makes some direct comments to the learner in a friendly and polite tone.	The video uses words (narration / text) in conversational style rather than formal style. The video relies on first and second-person statements (you, I, we, our) rather than distant third-person statements. The video uses some complex words (narration / text) or difficult language. The video makes some direct comments to the learner in a friendly and polite tone.	The video uses words (narration / text) in conversational style rather than formal style. The video relies on first and second-person statements (you, I, we, our) rather than distant third-person statements. The video uses simple and casual language and avoids overly professional or complex words (narration / text). The video involves sentences that speak directly to the learner, in a friendly and polite tone instead of just giving orders.
I11 VOICE	The video is narrated by a machine-synthesized voice rather than a human voice. The narrator's accent is not an issue. The narration's quality is not an issue.	The video is narrated by a human voice rather than a machine voice. The narrator's accent is not an issue. The video is recorded with low quality.	The video is narrated by a human voice rather than a machine voice. The narrator speaks English with a noticeable foreign accent. The video is recorded professionally with high quality.	The video is narrated by a human voice rather than a machine voice. The narrator speaks clear English (no noticeable foreign accent). The video has a low-quality audio (not recorded professionally).	The video is narrated by a human voice rather than a machine voice. The narrator speaks clear English (no noticeable foreign accent). The video is recorded professionally with high quality.

MPR DETAILED FORM

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	VERY POOR 1	POOR 2	FAIR 3	GOOD 4	EXCELLENT 5
I12 IMAGE	The narrator's image (whether as a static image, a talking head, or an animated character with low human like motion) is showing on the screen all the time throughout the presentation of the learning content, so it clashes with the presentation of all of the complex visuals.	The narrator's image (whether as a static image, a talking head, or an animated character with low human like motion) is showing on the screen when presenting most of the learning content, and it clashes with the presentation of most of the complex visuals.	The narrator's image (whether as a static image, a talking head, or an animated character with low human like motion) is showing on the screen when presenting some parts of the learning content, and it clashes with the presentation of some complex visuals.	The narrator's image (whether as a static image, a talking head, or an animated character with low human like motion) is not showing on the screen when presenting most of the learning content, and it does not clash with the presentation of complex visuals.	The narrator's image (whether as a static image, a talking head, or an animated character with low human like motion) is not showing on the screen when presenting the learning content.
I13 EMBODIMENT	The video has an on-screen agent with no embodiment (static image). The on-screen agent is standing motionless, without any eye gaze, pointing, facial expressions, human-like gesturing, or movements. The on-screen agent is considered neutral or dislikable rather than likable.	The video has an on-screen agent with a low embodiment rather than a high embodiment. The on-screen agent does not interact enough with learners / viewers because of lack of eye gaze, pointing, facial expressions, human-like gesturing & movements. The on-screen agent may be considered likable, neutral, or dislikable.	The video has an on-screen agent with a medium embodiment. The on-screen agent is interacting with learners / viewers by displaying an average amount of eye gaze, pointing, facial expressions, human-like gesturing & movements. The on-screen agent is considered likable rather than neutral or dislikable.	The video has an on-screen agent with a high-medium embodiment. The on-screen agent is interacting with learners / viewers by displaying a reasonable amount (not high) of eye gaze, pointing, facial expressions, human-like gesturing & movements. The on-screen agent is considered likable rather than neutral or dislikable.	The video has an on-screen agent with a high embodiment rather than a low embodiment. The on-screen agent is interacting with learners / viewers by displaying high quality eye gaze, pointing, facial expressions, human-like gesturing & movements. The on-screen agent is considered likable rather than neutral or dislikable.
I14 DYNAMIC DRAWING	The instructor points to already drawn visuals rather than drawing the related visuals while lecturing throughout the whole video. The video does not involve a writing instrument on the screen. (No drawing & no gradual appearance of visuals)	The instructor points to already drawn visuals rather than drawing the related visuals while lecturing throughout the whole video. The video does not involve a writing instrument on the screen but the related visuals are appearing gradually while the instructor is lecturing (as images instead of being drawn). (No drawing but the visuals are gradually appearing)	The instructor draws related visuals while lecturing rather than pointing to already drawn visuals throughout most of the video. The writing instrument / the instructor's hand is not shown while drawing the visuals throughout the whole video (Khan Academy style). (Drawing visuals while lecturing but not showing the instrument)	The instructor draws related visuals while lecturing rather than pointing to already drawn visuals throughout most of the video. The video contains some instances showing the instructor's body, particularly the hand while drawing the visuals. (Drawing most of the visuals while showing the instrument / hand)	The instructor draws related visuals while lecturing throughout the whole video rather than pointing to already drawn visuals. The instructor's body, particularly the hand is shown on the screen while drawing visuals. (Drawing all of the visuals while showing the instrument / hand)
I15 GAZE GUIDANCE	The on-screen instructor / agent looks exclusively at the learning content, or exclusively at the learners / camera while lecturing rather than shifting gaze between the learning content and the learners / camera throughout the whole video. The instructor / agent's gaze is not used at all to direct learners to look at the relevant information on the screen.	The on-screen instructor / agent looks exclusively at the learning content, or at the learners / camera while lecturing rather than shifting gaze between the learning content and the learners / camera throughout most of the video. The instructor / agent's gaze is used few times to direct learners to look at the relevant information on the screen.	The on-screen instructor / agent shifts gaze between the learning content and the learners / camera while lecturing rather than looking only at the learning content or only at the learners / camera throughout some parts of the video. The instructor / agent's gaze is used sometimes to direct learners to look at the relevant information on the screen.	The on-screen instructor / agent shifts gaze between the learning content and the learners / camera while lecturing rather than looking only at the learning content or only at the learners / camera throughout most of the video. The instructor's / agent's gaze is directing learners to look at the relevant information on the screen most of the time.	The on-screen instructor / agent shifts gaze between the learning content and the learners / camera while lecturing rather than looking only at the learning content or only at the learners / camera throughout the whole video. The instructor's / agent's gaze is always directing learners to look at the relevant information on the screen.
I16 SUBTITLE	There are no subtitles at all in the video. The video has a fast-paced narration. (Not good for non-native speaker learners especially, according to the Subtitle principle)	There are no subtitles at all in the video. The video has a slow-paced narration. (Not good for non-native speaker learners, according to the Subtitle principle) **OR** There are nonoptional subtitles in the video. The video has a fast-paced narration. (Not good for both non-native learners, according to the Subtitle principle, and native speaker learners, because of the redundancy effect)	There are nonoptional subtitles in the video. The video has a slow-paced narration. (Good for non-native speaker learners but not for native learners, because of the redundancy effect) **OR** There are optional subtitles in the video which learners / viewers can activate if they need. The video has a fast-paced narration. (Not good for non-native speaker learners according to the Subtitle principle)	There are nonoptional subtitles in the video. The video does not have a narration. (Good for non-native speaker learners but not for native learners, because of the modality effect)	There are optional subtitles in the video which learners / viewers can activate if they need. The video has a slow-paced narration. (Good for both native & non-native speaker learners)

Appendix B

MPR QUICK FORM	VERY POOR 1	POOR 2	FAIR 3	GOOD 4	EXCELLENT 5
I01 COHERENCE	Unrelated multimedia elements, distracting backgrounds.	Mostly unrelated elements.	Some unrelated elements.	Mostly relevant elements, clear background OR all elements relevant but with distracting background.	All elements relevant, clear background.
I02 SIGNALING	No key elements highlighted.	Few key elements highlighted.	Some key elements highlighted.	Most key elements highlighted OR all key elements highlighted but with poor emphasis choices.	All key elements effectively highlighted.
I03 REDUNDANCY	Narrator reads all on-screen text.	Narrator reads most text.	Narrator sometimes reads text.	Rarely reads text.	Narration explains visuals with only key text on screen OR only text is used with no narration.
I04 SPATIAL CONTIGUITY	Related text & visuals are far apart.	Most are far apart.	Some are close together.	Most are close together.	All are close together.
I05 TEMPORAL CONTIGUITY	Text & visuals never appear simultaneously.	Mostly not simultaneous.	Sometimes simultaneous.	Mostly simultaneous.	Always simultaneous.
I06 MULTIMEDIA	No visuals, only text/narration.	Few relevant visuals.	Some visuals, but insufficient.	Mostly well-supported visuals.	Always relevant visuals.
I07 SEGMENTING	Fast pace, too much information.	Mostly fast-paced.	Some learner-paced sections.	Mostly learner-paced OR video is part of a series with clear segmentation.	Fully segmented, learner-paced OR entire series is segmented for learners.
I08 PRE-TRAINING	No introduction or key terms.	Minimal introduction, no key terms.	Brief introduction, no key terms.	Introduction with key terms, references to other videos for details.	Full introduction with key terms and concepts.
I09 MODALITY	Only text explains visuals.	Mostly text, minimal narration.	Mixed, without clear consideration of complexity.	Narration for complex visuals, text for simple ones.	Narration supports visuals, text used only for labels.
I10 PERSONALIZATION	Formal, impersonal language.	Mostly formal, few direct addresses.	Some conversational tone.	Mostly conversational, engaging.	Fully conversational, engaging, and friendly.
I11 VOICE	Machine-generated voice.	Low-quality human voice.	Human voice with a strong accent.	Clear human voice, low recording quality.	High-quality, clear human voice.
I12 IMAGE	Narrator always on-screen, distracting.	Mostly on-screen, somewhat distracting.	Sometimes on-screen, minor distraction.	Rarely on-screen, no distraction.	Never on-screen.
I13 EMBODIMENT	Static image, no gestures.	Limited movement, minimal engagement.	Moderate gestures and facial expressions.	Frequent gestures, engaging.	Highly expressive gestures, natural interaction.
I14 DYNAMIC DRAWING	Only pre-drawn visuals.	Gradually appearing visuals.	Some hand-drawn visuals, hand not shown.	Mostly drawn visuals, hand sometimes shown.	Fully drawn visuals, hand/instrument visible.
I15 GAZE GUIDANCE	Instructor stares at content or camera only.	Mostly fixed gaze.	Occasionally shifts gaze to guide attention.	Frequently shifts gaze to direct attention.	Always shifts gaze to guide attention.
I16 SUBTITLE	No subtitles, fast narration.	No subtitles, slow narration OR mandatory subtitles with fast narration.	Mandatory subtitles, slow narration OR optional subtitles, fast narration.	Mandatory subtitles, no narration.	Optional subtitles, slow narration.